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(19)

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(54) PRODUCTION OF A MOULDED, BONDED, NON-WOVEN, FIBROUS PRODUCT

(71) We, IMPERIAL CHEMICAL INDUSTRIES LIMITED, Imperial Chemical House, Millbank, London SW1P 3JF, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the production of a moulded, bonded, non woven, fibrous product.

It is known to produce such a product by compressing an open (e.g. carded) web comprising crimpable and bondable bicomponent fibres, which comprise a first polymer component and a second polymer component integral therewith along at least a portion of the exterior thereof, the second polymer component having a softening temperature substantially lower than that of the first polymer component, and then heating the web to crimp the bicomponent filaments and to effect interfibre bonding. It is also known to produce such a product by initially heating crimpable and bondable bicomponent fibres at a temperature sufficient to crimp and stabilise the fibres without effecting interfibre bonding, forming the fibres into an open (e.g. carded) non woven web, heating the web to a temperature sufficient to effect interfibre bonding, and cooling the web to form a bonded, integral structure.

With the former method, because of the time required to heat the compressed web throughout to the interfibre bonding temperature, there is a tendency for excessive heating to occur at the centre of the web which results in the formation of an undesirable fused mass. The latter method has the disadvantage that without the use of pressure, the web can only loosely be conformed to the shape of a mould prior to effecting interfibre bonding.

The present invention seeks to provide a method wherein conformation by pressure may be utilised without the attendant disadvantage of localised excessive heating.

Therefore, according to the present invention, a method for the production of a moulded, bonded, non woven, fibrous, product is provided in which:—

(a) an open web of heat stabilised, crimped fibres, at least 20% by weight of which comprise bondable bicomponent fibres having a first polymer component and a second polymer component integral therewith along at least a portion of the exterior thereof, the second polymer component having a softening temperature lower than that of the first polymer component, is subjected to a heat treatment at a temperature in excess of the softening temperature of the second polymer component but below the softening temperature of the first polymer component to effect interfibre bonding, and

(b) the web is compressed to the desired density and shape whilst being maintained at or in excess of the softening temperature of the second polymer component, and then caused or permitted to cool.

The term "bicomponent fibre" refers to composite fibres formed by the co-spinning of at least two polymer components, e.g. in an eccentric sheath/core or side/side configuration. Fibres of three or more components are included in this definition. By "fibre" is meant a fibre of staple length of 0.5 to 6 inches, preferably from 1 to 5 inches.

It has surprisingly been found that non woven products having a low density can only be obtained by effecting the interfibre bonding at a temperature of not more than 15°C in excess of the softening temperature of the second polymer compouent.

The initial, open web of heat stabilised, crimped fibres may be formed by carding fibres which have previously been crimped and heat stabilised; it may be formed by heating a web of crimpable fibres to effect crimping and substantial heat stabilisation thereof and then re-carding the web; it may also be formed by heating a web composed of crimpable fibres and previously crimped/heat stabilised fibres to crimp and heat stabilise the former fibres, and then re-carding the web to open it.

It may be unnecessary to open the crimped

fibre web by re-carding, and the development of any crimp and the interfibre bonding of the bicomponent fibres may be effected in a single heat treatment. Webs containing bicomponent fibres of the "reversible crimp" type as described, for example, in Example 1 of U.K. Patent Specification No. 1,073,181, are particularly suitable for the development of crimp and interfibre bonding in a single heat treatment.

Preferably, the initial web comprises at least 50% of crimped, bondable bicomponent fibres which have been heat stabilised, and, most desirably, is composed wholly of such fibres. In those circumstances when other fibres are present, those other fibres are crimped and are heat stabilised under the conditions prevailing for the bicomponent fibres, and also, preferably, are compatibly bondable.

The density of the open web of the heat stabilised, crimped fibres (which may be wholly bondable bicomponent fibres, or a mixture of these fibres with other fibres) is conveniently the natural carded density, i.e. that normally produced by the carding machine, which, though variable, is usually of the order of 0.005 gm/cm^3. If desired, of course, the density may be varied to suit the density required in the final product. The web may be built up to varying thicknesses, if desired, by utilisation of a cross-lapping machine.

Normally the fibres may have a denier within a wide range, for example, from 1 to 50 denier. Conveniently, fibres having a denier in the range 5 to 30 are employed.

Once the open web has been prepared it is then laid down on a supporting surface or in a mould. It is then heated to effect inter-fibre bonding and whilst in this condition it is compresed by means of a platen or other suitable shaped mould-part to the desired extent. The compressed web is then allowed to cool or is cooled before being removed. By this process, it is is possible to form a bonded, non woven, fibrous product in many forms, including sheets, cubes, and complex moulded shapes.

Excessive compression is avoided in order to produce a product having a low density, high porosity, open "sponge-like" structure and not a high density "felt-like" structure. Compression ratios between 2:1 to 9:1 may be used, preferably 2:1 to 6:1. Various heating methods may be employed to effect interfibre bonding but a preferred method is to pass a heated gaseous fluid, for example a gas or mixture of gases, or steam, through the web. To facilitate such heating the supporting surface or mould may be readily permeable to such gaseous fluids.

The bicomponent fibres may comprise a variety of synthetic, organic polymers such, for example, as (co-)polyolefins, (co-)polyesters, and (co-)polyamides. The bicomponent fibres may be mixed with other synthetic, organic, polymeric fibres provided these, when crimped and heat stabilised, do not soften at the temperature of softening of the second polymer component of the bicomponent fibres.

Active particles may be incorporated into the bonded, non woven, fibrous product during any convenient stage of its manufacture. By the terms "active particles" is meant particles which chemically or physically modify the properties of the fibrous product, and includes active carbon, electrically conductive carbon particles, and ion exchange resins. The particles may be held in the web by simple entrapment within the fibres and/or by adhesion to and/or penetration of the bondable component of the bicomponent fibre.

The process of the present invention is particularly suitable for the manufacture of bonded, non woven, fibrous products having a thickness in excess of one inch. This is because the web is in an open state and not under compression when subjected to the heat treatment to effect interfibre bonding. Consequently heat may be transmitted relatively rapidly to the centre of the web without the outer layers of the web being subjected to prolonged heating resulting in degradation thereof.

The products of the invention may be utilised in the production of toys, pillows, mattresses, upholstery, filtration media and air flow stabilisers, for example. A particular end use lies in such a product incorporating active particles for the treatment of various media, such as liquids and gases, in such a way that the medium being treated has the fullest access to the surface of the particulate matter without the particles being lost in the fluid flow or being able to agglomerate or sediment. Another particular end use lies in such a product coated and/or impregnated with thermally and/or chemically settable materials, which are then allowed or caused to set to produce useful composite materials.

Examples of suitable settable materials include resins, particulary polyester resins, cements and polyurethanes, preferably polyurethane foams.

The composite materials may be produced by inserting appropriately shaped blocks of sheets of the moulded, bonded, non woven, fibrous structure into a mould and introducing the requisite amount of settable material thereinto, and thereafter causing or allowing the settable material to set. If it is desired that the settable material shall only partially penetrate into the fibrous structure, then the pressure in the mould is suitably governed. For example, if the resin is a foamed polyurethane and air is not allowed to escape from the mould, then the foam will not fully penetrate the fibrous structure. Conversely, if provision is made for the air to escape, such as by air bleed holes, the foam will completely fill the mould and thereby impregnate the

fibrous structure. By selection of appropriate conditions it is possible to vary between a situation wherein the fibrous structure is merely coated to one wherein it is completely impregnated.

Advantages of using the fibrous structure, made according to the present invention as a reinforcement are, inter alia,

(i) it is a very light structure but, being bonded, maintains its form.

(ii) the fibrous structure has inherent shape retention, and as a result may be used to reinforce selected localities of a moulded settable material without recourse to shape retaining systems for the fibrous structure.

The invention will be further described with reference to the following Examples.

EXAMPLE I.

Staple fibre of 10 denier per filament and 2 inch staple length in a 50:50 side/side configuration of nylon 66 (polyhexamethylene-adipamide) and nylon 11 (poly-omega-amino-66, respectively, was fully opened by one passage through a Tatham carding machine and the web was cross lapped to form a very lofty batt of fibres of 3.5 inch thickness. This matt was then passed through an oven supported on a conveyor and a mixture of air and steam at 180°C. was blown through the batt for 1.5 minutes. [Because the staple fibres used were of the "reverse helical crimp" type it was not necessary to crimp and heat stabilise the fibres in the batt and then to re-open the batt prior to heating to bond the fibres.] This heat treatment effected initially the crimp development of the fibres and then softened the nylon 11 component to effect the interfibre bonding. As the batt left the oven it was immediately compressed to a thickness of 2 inches and cooled. The resultant resilient bonded fibrous product had a bulk density of 0.019 gm/cm³.

EXAMPLE II.

Staple fibre of 20 denier per filament and 2 inch staple length in a 50:50 eccentric sheath/core configuration of nylon 6 and nylon 66, respectively, was fully opened by one passage through a Tatham carding machine and built up to a 2 inch thick batt on a lap wheel. This batt was heated in a nitrogen atmosphere at 180°C. for one minute to fully develop fibre crimp and then cooled. This compacted batt was then broken up and recarded to form an open lofty batt of 2 inch thickness. A hot nitrogen/air mixture at 230°C. was passed through the batt for 0.5 minutes, and then the batt was compressed to half its thickness and cooled. The bonded fibrous product had a density of 0.025 gm.cm³.

EXAMPLE III.

Staple fibre of 3 denier per filament and 2 inch staple length in a 2:1 core/sheath configuration of polyethylene terephthalate and a copolymer thereof with 20 mole % adipate, respectively, was fully opened by one passage through a Tatham carding machine and formed into a batt of 4 inches thickness. This batt was then heated for 1 minute in air at 165°C. to fully develop crimp and cooled. This batt was then re-opened by being passed again through the carding machine and formed into a new lofty batt of 4 inches thickness. Hot air at 205°C. was passed for 1 minute through the batt which was then compressed to half its thickness and cooled. A bonded fibrous product of density 0.01 gm/cm³ was obtained.

EXAMPLE IV.

The staple fibre of Example I was formed into a low density (0.005 gm/cm³) lofty batt as previously described. The batt was placed into a mould (formed of wire mesh) so that it projected above the mould which was in the shape of a teddy bear. Care was taken to prevent any compaction of the batt occurring. Air at 185°C. was then blown through the mould for 2.5 minutes, the batt then compressed into the mould and allowed to cool while compressed. A moulded, bonded fibrous teddy bear resulted which was resilient and had a pleasant textile handle.

EXAMPLE V.

During the production of a bonded fibrous product in accordance with Example I, active carbon particles (Pittsburg Active Carbon Co., Pennsylvania, U.S.A.) were incorporated therein during the crosslapping stage by sprinkling the particles over its lap. The resultant product incorporating the active carbon particles was immersed in an aqueous solution of Solochrome Cyanine R200 dye (Registered Trade Mark), and the solution was substantially decolourised.

The product also decolourised commercial grade paraffin which contained a soluble red dye.

EXAMPLE VI.

Example V was repated except that the active carbon particles were replaced by 10 gm of Dowex K21 (Registered Trade Mark) ion exchange resin in a bonded fibrous structure of volume 290 cm³.

A standard sample of hard water was prepared containing 100 ppm of calcium carbonate. The fibrous structure with the ion exchange resin particles was immersed in the solution. After stirring the solution so that it flowed through the structure for 3 minutes the level of the calcium carbonate was found to have been reduced to 8 ppm.

EXAMPLE VII.

Staple fibre of 12 denier per filament and

2 inch staple length in a 2:1 core/sheath configuration of poly(ethylene terephthalate) and a copolymer thereof with 20 mole % isophthalate, respectively, was fully opened by one passage through a Tatham carding machine and formed into a batt of 6 inches thickness. This batt was then heated for 1 minute in air at 170°C. to fully develop crimp and cooled. This batt was then re-opened by passing through a carding machine and laid into a batt 6 inches thick with a density of .006 g/cc. Hot air at 209°C. was passed through the batt for 1½ minutes which was then compressed to 2 inches thick. A bonded fibrous product of density .015 g/cc was obtained.

EXAMPLE VIII.

Staple fibre of 6 denier per filament and 2 inch staple length in a 2:1 core/sheath configuration of polypropylene and polyethylene, respectivey, was fully opened by one passage through a "Shirley" (Registered Trade Mark) miniature carding machine and formed into a batt of 2 inches thickness. The batt was heated in air for 1½ minutes at 80°C to fully develop crimp and cooled. The batt was reopened by being passed through the carding machine and formed into a 2" thick batt of density .007 g/cc. The batt was heated in an air oven for 1 minute, compressed to ½" thickness and cooled. A fibrous product of density .023 g/cc was obtained.

EXAMPLE IX.

Staple fibre of 14 denier per filament and 2" staple length in a 1:1 core/sheath configuration of poly(ethylene terephthalate) and polypropylene was fully opened by one passage through a "Shirley" (Registered Trade Mark) miniature carding machine and formed into a batt 1½ inches thick. The batt was heated for 1 minute at 170°C, compressed to ½ inch thick and cooled. A fibrous product of .029 g/cc was obtained.

The following Experiments A to S show how the density of the bonded web before compression can be adjusted by varying the bonding temperature. It will be obvious that variation of the density of the uncompressed bonded web can be used to vary the density of the final shaped, bonded web.

EXPERIMENTS A to F.

Heterofil staple used in Example VII was fully opened by one passage through a Tatham carding machine and cross laid to form a batt 15 cm thick. Portions of the batt were heated for 1½ minutes in an air oven maintained at various temperatures indicated in the Table. The densities of the resulting non woven products are given in the Table.

EXPERIMENTS G to K.

Heterofil staple used in Example VII was fully opened by one passage through a Tatham carding machine and cross laid to form a batt 15 cm. thick. The batt was heated in an air oven at 180°C. for one minute to develop the crimp of the bicomponent fibres. It was then cooled, recarded and cross laid to from a batt 15 cm. thick. Portions of this second batt were heated for 1½ minutes in an air oven maintained at various temperatures indicated in the Table. The densities of the resulting non woven products are given in the Table.

EXPERIMENTS L to S.

Heterofil staple used in example I was fully opened by one passage through a Tatham carding machine and cross-laid to from a batt 15 cm. thick. A portion of this batt was heated in an air oven for 1½ minutes at the temperatures given in the table, and then cooled. The densities of the resulting non woven products are given in the table.

Experiment	Bonding Temp. (°C)	Density (g.per cc) of bonded, non woven product
A	207	0.023
B	210	0.031
C	215	0.037
D	220	0.060
E	225	0.064
F	230	0.073
G	207	0.016
H	210	0.018
I	215	0.032
J	220	0.056
K	225	0.056
L	180	0.010
M	185	0.010
N	190	0.012
O	195	0.015
P	200	0.023
Q	205	0.022
R	210	0.030
S	215	0.039

EXAMPLE X.

A moulded, bonded, non woven fibrous structure in the form of a sheet 2 inches thick was made according to Example I.

A conventional polyurethane mould was lined with the sheet of fibrous structure and a catalysed polyurethane foam was poured into the mould and allowed to foam against the fibrous structure. No air bleed holes were provided in the mould so that air was trapped within the fibrous structures. As the polyurethane foamed a pressure of approximately 5 psi was developed compressing the trapped air and allowing the polyurthane to penetrate about 0.25 inches into the fibrous structure. On curing, i.e. setting, the resultant composite fibrous structure was removed from the mould. The composite fibrous structure was composed of the fibrous structure having a foamed polyurethane penetrative coating on one side.

EXAMPLE XI.

Example X was repeated using a mould having appropriate air bleed holes. The air was displaced and the resultant fibrous composite was composed of the fibrous structure wholly impregnated with the foamed polyurethane.

EXAMPLE XII.

A moulded, bonded, non-woven, fibrous structure was made according to Example I and a portion thereof was placed in a glass beaker. A low viscosity, polyester casting resin was poured onto the fibrous structure and completely penetrated the structure excluding the air therefrom. After polymerisation of the resin, a fibrous composite composed of the fibrous structure wholly impregnated with the resin resulted.

WHAT WE CLAIM IS:—

1. A method for the production of a moulded, bonded, non woven, fibrous product in which:—

(a) an open web of heat stabilised, crimped fibres, at least 20% by weight of which comprise bondable bicomponent fibres, as hereinbefore defined, having a first polymer component and a second polymer component integral therewith along at least a portion of the exterior thereof, the second polymer component having a softening temperature lower than that of the first polymer component, is subjected to a heat treatment at a temperature in excess of the softening temperature of the second polymer component but below the

softening temperature of the first polymer component to effect interfibre bonding, and, (b) the web is compressed to the desired density and shape whilst being maintained at or in excess of the softening temperature of the second polymer component, and then caused or permitted to cool.

2. A method for the production of a moulded, bonded, non woven, fibrous product according to claim 1 wherein the open web of fibres is subjected to a heat treatment at a temperature of not more than 15°C in excess of the softening temperature of the second polymer component to effect interfibre bonding.

3. A method according to claim 1 or 2 wherein the open web of heat stabilised, crimped fibres is formed by carding fibres which have previously been crimped and stabilised.

4. A method according to claim 1 or 2 wherein the open web of heat stabilised, crimped fibres is formed by heating a web of crimpable fibres to effect crimping and substantial heat stabilisation thereof, and then re-carding the web.

5. A method according to claim 1 or 2 wherein the open web of heat stabilised, crimped fibres is formed by heating a web composed of crimpable fibres and previously crimped/heat stabilised fibres to crimp and heat stabilise the former fibres, and then re-carding the web.

6. A method according to claim 1 or 2 wherein the crimp and interfibre bonding of the bicomponent fibres are effected in a single heat treatment.

7. A method according to claim 1 or 2 wherein the bicomponent fibres are of the reversible crimp type.

8. A method according to any one of the preceding claims wherein the open web comprises at least 50% of crimped, bondable bicomponent fibres.

9. A method according to any one of claims 1 to 7 wherein the open web is composed wholly of crimped bondable fibres.

10. A method according to any one of the preceding claims wherein a compression ratio of 2:1 to 9:1 is used.

11. A method according to any one of claims 1 to 9 wherein a compression ratio of 2:1 to 6:1 is used.

12. A method according to any one of the preceding claims wherein a heated gaseous fluid is passed through the web to effect interfibre bonding.

13. A method according to any one of the preceding claims wherein the bicomponent fibres are formed from a polyolefin and/or a copolyolefin.

14. A method according to any one of claims 1 to 12 wherein the bicomponent fibres are formed from a polyester and/or a copolyester.

15. A method according to any one of claims 1 to 12 wherein the bicomponent fibres are formed from a polyamide and/or a copolyamide.

16. A method according to any one of the preceding claims wherein active particles are introduced into the web during its formation.

17. A method according to claim 16 wherein the active particles are adhered to and/or penetrate the outer surface of the bondable component of the bicomponent fibre.

18. A moulded, bonded, non woven, fibrous product produced by a method according to any one of the preceding claims.

19. A moulded, bonded, non woven, fibrous product according to claim 18 coated and/or impregnated with a thermally and/or chemically settable material which has been allowed or caused to set.

20. A fibrous product according to claim 19 wherein the settable material is a polyurethane.

21. A method for the production of a moulded, bonded, non woven, fibrous product substantially as hereinbefore described with reference to the Examples.

22. A moulded, bonded, non woven, fibrous product substantially as hereinbefore described with reference to the Examples.

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